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THE FIELD ARTILLERY OFFICER'S HANDBOOK

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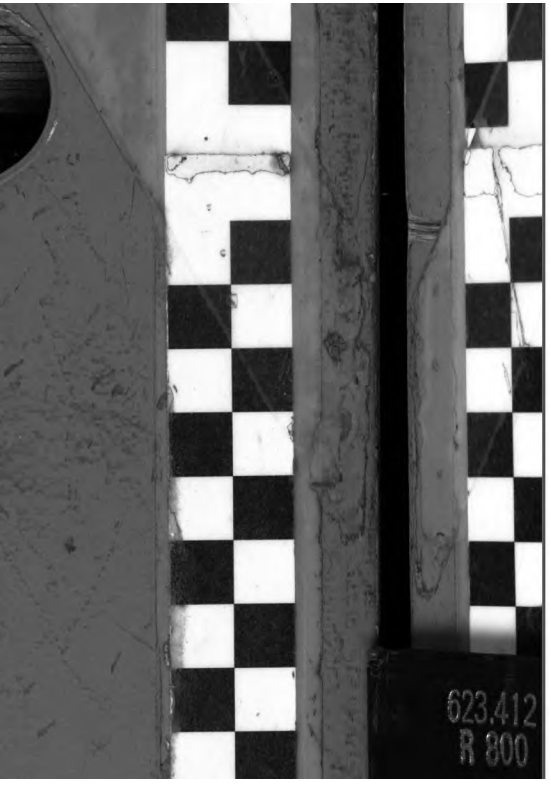

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THE FIELD ARTILLERY OFFICER'S HANDBOOK

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THE FIELD ARTILLERY OFFICER'S HANDBOOK

BY

C. F. THOMSEN

FORMERLY SGT. AUSTRALIAN FIELD ARTILLERY
A.I.F.

SEVEN ILLUSTRATIONS

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TABLES.

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TABLE 1.—Range Table. 18 pr. Q.F.

Remaining Velocity.	5 Min. Elev. or Dep. alters Point of Impact.		Angle of Descent.	Elevation.	Range. Yards.	Fz. Scale for Fz. T.P. No. 80.	Fz. Scale for Fz. T.P. No. 85.	50 per cent. of Rounds should fall in		Time of Flight.
	Range. Yards.	Vertically Lal., and Fally. Yards.						Length. Yards.	Breadth. Yards.	
1 439	67	0·72	0°47′	0°36′	**500**	1·2	0·9	6	0·2	1·01
1 295	58	1·45	1·39	1·17	**1 000**	2·7	2·0	12	0·4	2·13
1 183	50	2·18	2·38	2·2	**1 500**	4·2	3·2	17	0·7	3·33
1 095	44	2·91	3·47	2·55	**2 000**	5·8	4·5	22	1·0	4·63
1 028	39	3·63	5·10	3·54	**2 500**	7·4	5·9	27	1·4	6·03
976	35	4·36	6·48	5·1	**3 000**	9·0	7·4	31	1·8	7·52
936	32	5·09	8·37	6·14	**3 500**	10·6	8·9	35	2·4	9·09
904	30	5·81	10·40	7·32	**4 000**	12·3	10·5	38	3·0	10·28
876	28	6·54	12·54	8·58	**4 500**	14·0	12·2	42	3·8	12·55
847	26	7·27	15·18	10·29	**5 000**	15·8	13·9	45	4·7	14·40
821	24	8·00	17·58	12·9	**5 500**	17·7	15·7	48	5·7	16·35
798	23	8·73	20·47	13·57	**6 000**	19·7	17·6	50	6·8	18·41
778	21	9·45	23·56	15·54	**6 500**	21·8	19·5	51	8·0	20·61
762	20	10·18	27·20	18·5	**7 000**	..	..	52	9·4	22·98

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TABLE 2.—Variations.

Range.	100 F. s. Variation in M.V. alters Range by	Barometer, 1 inch Variation alters Range by	Air Temperature, 10° F. Variation alters Range by	Charge Temperature, 10° F. Variation alters Range by	
				N.C.T. 4 F. s.	Cordite 10 F. s.
Yds.	Yds.	Yds.	Yds.	Yds.	Yds.
500	54	3	2	2	5
1 000	96	7	4	4	10
1 500	136	11	7	6	14
2 000	170	16	10	7	17
2 500	198	21	13	8	20
3 000	218	27	16	9	22
3 500	234	33	20	9	23
4 000	248	40	24	10	25
4 500	260	47	28	10	26
5 000	270	54	32	10	27
5 500	280	61	37	11	28
6 000	290	69	42	12	29
6 500	298	77	46	12	30
7 000	306	86	52	12	30
7 500	314	95	57	12	31
8 000	322	104	62	13	32

Normal barometer, 30″. If bar. rises add range, and vice versa.

Normal temperature, 60°. If temp. rises deduct range, and vice versa.

Meteorological Telegrams.

4-figure group, 1st 2 figs. = time of flight, 2nd 2 figs. = temp. air.

5-figure group, 1st 2 figs. = wind velocity, 2nd 3 figs. = true bearing.

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Wind Table.

Explanation of Table.—For finding deflection and alteration to range caused by wind coming from any angle to L. of F.

For alteration to range use column R; for deflection in minutes, column D.

Example.—Range = 5 500 yards; wind, 20 ft. per sec.; angle to L. of F., 40° head. For a 30 ft. s. read alteration to range 112 yards and 22 min. deflection. $\frac{112 \times 2}{3} = +74$ = alteration to range, and $\frac{22 \times 2}{3} = 14$ min. Then range = 5 575 yards and 15 min. right or left. For a following wind the range would have been 5 425 yards.

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TABLE 3.—Wind Table. 30 F. s.

Range. Yards.	0°		10°		20°		30°		40°		50°		60°		70°		80°		90°	
	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.	R. Yds.	D. Min.
1 000	10	0	10	0	10	5	10	5	10	5	5	10	5	10	5	10	0	10	0	10
1 500	17	,,	17	,,	17	5	15	7	14	7	10	10	10	12	7	12	,,	12	,,	12
2 000	25	,,	25	,,	25	5	20	10	20	10	15	10	15	15	10	15	5	15	,,	15
2 500	37	,,	37	,,	34	7	32	10	30	12	22	12	20	15	15	17	7	17	,,	17
3 000	50	,,	50	5	45	10	45	10	40	15	30	15	25	15	20	20	10	20	,,	20
3 500	67	,,	64	5	60	10	57	12	52	17	42	20	32	20	25	25	12	25	,,	25
4 000	85	,,	80	5	75	10	70	15	65	20	55	25	40	25	30	30	15	30	,,	30
4 500	100	,,	100	5	95	12	90	17	80	20	67	25	50	27	40	30	17	32	,,	32
5 000	125	,,	120	5	115	15	110	20	95	20	80	25	60	30	45	30	20	35	,,	35
5 500	145	,,	140	5	135	15	127	20	112	22	95	27	72	32	52	32	25	37	,,	37
6 000	170	,,	165	5	160	15	145	20	130	25	110	30	85	35	60	35	30	40	,,	40
6 500	190	,,	190	7	180	17	165	22	150	27	125	40	97	40	70	40	32	45	,,	45
7 000	220	,,	215	10	205	20	190	25	170	30	140	45	110	45	80	45	35	50	,,	50

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Angle of Sight Table.

Explanation of Table.—For finding angle of sight from battery to target, the range to target in yards, and difference in height between battery and target in metres.

Example.—Range to target = 5 500, difference between target and battery 35 metres (obtained from contour map). Follow 35^{m} column down to 5 500 line, and read 24′ elevation or depression as the case may be on that line.

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TABLE 4.—Angle of Sight.

Range. Yards.	5m	10m	15m	20m	25m	30m	35m	40m	45m	50m	55m	60m	65m	70m	75m
	′	′	′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1 000	20	38	57	1 16	1 35	1 54	2 12	2 31	2 50	3 8	3 27	3 46	4 4	4 24	4 43
1 250	15	30	45	1 0	1 15	1 30	1 45	2 0	2 15	2 30	2 45	3 0	3 15	3 30	3 45
1 500	12	25	38	51	1 3	1 15	1 28	1 41	1 55	2 5	2 17	2 30	2 44	2 55	3 7
1 750	11	21	32	43	54	1 7	1 15	1 26	1 38	1 47	1 52	2 8	2 20	2 30	2 41
2 000	9	19	29	38	47	55	1 6	1 16	1 25	1 37	1 44	1 53	2 2	2 12	2 22
2 500	7	15	23	30	38	45	53	1 0	1 8	1 15	1 22	1 30	1 37	1 45	1 53
3 000	6	13	19	25	32	38	44	50	57	1 3	1 9	1 16	1 21	1 29	1 35
3 500	5	11	16	22	27	32	37	43	48	54	1 0	1 5	1 10	1 16	1 25
4 000	5	10	14	19	22	28	34	38	43	47	52	57	1 2	1 6	1 11
4 500	4	9	13	17	21	25	29	34	38	42	46	51	54	59	1 3
5 000	4	8	11	15	19	23	26	30	34	38	41	46	49	53	57
5 500	4	8	10	14	17	21	24	28	31	34	38	41	44	48	51
6 000	3	7	9	13	16	19	22	26	28	31	35	38	41	44	48

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Dead Ground and Clear Crest.

Explanation of Table.—Column A gives the angle of sight from muzzle of gun to crest of obstruction, and Q.E. of gun to clear crest. Column R will give the extreme range of gun after clearing crest. (Range from gun to crest and dead ground.)

To find Q.E. and Dead Ground.—Measure angle by means of a clinometer from height of muzzle of gun to crest, measure or estimate distance to crest in hundreds of yards. From A. of S. to crest in column A, *starting at the next line below the angle to crest, count down the column the same number of lines as there are hundreds of yards from gun to crest,* the angle at that place in column A will be the Q.E. of gun, and the figures in column R the range in yards after clearing crest. This will give the range on level ground; if on sloping ground, the A. of S. from gun to target will have to be added or deducted from the Q.E. and the range read off at that line. When A. of S. is + or *elevation, deduct*; when — or DEPRESSION, ADD.

Example.—Let it be required to find the gun position behind a crest of obstruction 2 500 yards from the target.

Select a convenient place, say, 600 yards behind the crest, measure the angle from the height of the muzzle of the gun to crest, say, 4°, then from 4° in column A count down six lines for 600 yards, and read Q.E. of gun 4° 45′ and range in column R = 2 880 yards. Then dead ground = 2 880 yards — 600 = 2 280 yards. In case the A. of S. to target had been 15 min. DEPRESSION, this angle should be ADDED to the Q.E., and the range read off opposite 5° = 2 990 yards; if 15 min. *elevation, subtract* and at 4° 30′ read off 2 770 yards. The Q.E. will remain the same as first read off, viz. 4° 45′.

Note.—Had the distance to crest from gun been 500 yards, only five lines should have been counted down.

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TABLE 5.—Dead Ground and Clear Crest.

A.	R.	A.	R.	A.	R.	A.	R.
° ′		° ′		° ′		° ′	
1 0	800	5 0	2 990	9 0	4 505	13 0	5 740
1 8	885	5 8	3 045	9 8	4 545	13 8	5 775
1 15	970	5 15	3 100	9 15	4 590	13 15	5 810
1 23	1 055	5 23	3 150	9 23	4 630	13 23	5 840
1 30	1 140	5 30	3 205	9 30	4 670	13 30	5 875
1 38	1 225	5 38	3 255	9 38	4 715	13 28	5 910
1 45	1 310	5 45	3 310	9 45	4 755	13 45	5 945
1 53	1 395	5 53	3 360	9 53	4 800	13 53	5 980
2 0	1 480	6 0	3 410	10 0	4 845	14 0	6 010
2 8	1 550	6 8	3 460	10 8	4 885	14 8	6 045
2 15	1 625	6 15	3 510	10 15	4 925	14 15	6 080
2 23	1 695	6 23	3 555	10 23	4 965	14 23	6 110
2 30	1 770	6 30	3 605	10 30	5 000	14 30	6 145
2 38	1 840	6 38	3 665	10 38	5 040	14 45	6 175
2 45	1 910	6 45	3 705	10 45	5 080	14 53	6 210
2 53	1 985	6 53	3 755	10 53	5 120	15 0	6 245
3 0	2 045	7 0	3 800	11 0	5 160	15 8	6 275
3 8	2 110	7 8	3 845	11 8	5 200	15 15	6 305
3 15	2 170	7 15	3 895	11 15	5 235	15 23	6 340
3 23	2 235	7 23	3 940	11 23	5 270	15 30	6 370
3 30	2 300	7 30	3 985	11 30	5 310	15 45	6 460
3 38	2 360	7 38	4 030	11 38	5 345	15 53	6 495
3 45	2 425	7 45	4 080	11 45	5 380	16 0	6 525
3 53	2 485	7 53	4 125	11 53	5 420	16 8	6 555
4 0	2 545	8 0	4 170	12 0	5 455		
4 8	2 600	8 8	4 215	12 8	5 490		
4 15	2 660	8 15	4 255	12 15	5 530		
4 23	2 715	8 23	4 295	12 23	5 565		
4 30	2 770	8 30	4 340	12 30	5 600		
4 38	2 825	8 38	4 380	12 38	5 635		
4 45	2 880	8 45	4 420	12 45	5 670		
4 53	2 940	8 53	4 460	12 53	5 705		

See note on p. 44.

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TABLE 6.—Corrector.

Range. Yards.	To alter Burst 10′, alter Cor. by	Effective Burst—Short. Yds.	Effective Burst—Height. Feet.
1 000	—	—	5
2 000	11	80	15
3 000	7	70	25
4 000	5	60	35
5 000	4	55	45
6 000	3	50	55

Fuze correction setting ± 1, 2, 3, 4.
Corrected corrector ± 3, 5, 8, 13.

TABLE 7.—Angular Height of 18 pr. Burst.

From Forward Observing Station.

Range. Yards.	Distance of O.P. from Target in Yards.									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1 000**
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
2 000	3 10	1 35	1 5	0 50	0 40	0 30	0 25	0 25	0 20	0 20
3 000	..	2 35	1 40	1 15	1 0	0 50	0 45	0 35	0 30	0 30
4 000	..	3 35	2 25	1 50	1 25	1 10	1 0	0 55	0 50	0 45
5 000	..	..	3 5	2 30	1 50	1 30	1 20	1 10	1 0	0 55
6 000	..	..	3 55	2 50	2 15	1 55	1 35	1 25	1 15	1 10

2° diff. A. of S. = 1 point of diff. in corrector (drop = +).
1″ fall of bar. = minus 6 of corrector.
Normal corrector (bar., 30″) = 150.
Fall of 10 F. s. M.V. alters corrector 1 point.
(Calibration and temp. charge = minus.)

Fuzes under 1 600 yards = $\frac{\text{Range in 100 yards}}{4} + \frac{1}{2}$.

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TABLE 8.—Corrections to Range for Fuzes.

(Fz. 80, Aluminium, taken as Normal.)

85 Fz.		80 Fz. (brass).	
Range.	Correction.	Range.	Correction.
Yds.	Yds.	Yds.	Yds.
Below 2 000	± 0	Below 2 500	+ 25
2 000–4 000	+ 25	2 500–3 500	± 0
4 000–5 000	+ 50	3 500–5 500	− 25
5 000–6 000	+ 75	5 500 & above	− 50
6 000 & above	+ 100	..	..

H.E. No. 100 type. All ranges — 25 yards.

TABLE 9.—Angular Width of 4- and 6-Gun Batteries.

6-Gun, 100 Yards; 4-Gun, 60 Yards.

Yds.	° ′	° ′
2 000	3 0	1 45
3 000	2 0	1 10
4 000	1 30	0 50
5 000	1 0	0 40
6 000	1 0	0 35
Range	6-gun, 100 yds.	4-gun, 60 yds.

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Calibration (amtn. of same lot).

Use shrapnel, Fz. 80, and all propellants.

Use datum point at normal range (exact map, reference and contour, known).

Little or no wind.

Correct map range for air, bar., wind, and charge.

Obtain 6 pluses and 6 minuses.

Note difference of range.

Multiply 100 F. s. by found error in yards, and ÷ by error caused by 100 F. s. at corrected map range.

Deduct found error from 1 615 = new M.V.

Paint on shield number of gun and new M.V. for N.C.T. and cordite, and necessary correction in yards for various ranges.

Corrections for Difference in M.V.

1 650 F. s.

Below 1 200 yds.	Subtract 25 yds.
From 1 200 to 2 200 yds. . . .	„ 50 „
„ 2 200 „ 4 100 „ . . .	„ 75 „
„ 4 100 „ 8 000 „ . . .	„ 100 „

1 640 F. s.

Below 1 700 yds.	Subtract 25 yds.
From 1 700 to 4 100 yds. . . .	„ 50 „
Above 4 100 yds.	„ 75 „

1 630 F. s.

Below 4 100 yds.	Subtract 25 yds.
Above „ „	„ 50 „

1 620 F. s.

Below 4 100 yds.	Subtract 0 yds.
Above „ „	„ 25 „

1 610 F. s.

Below 4 100 yds.	Add 0 yds.
Above „ „	„ 25 „

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1 600 F. s.

Below 4 100 yds.	Add 25 yds.
Above „ „	„ 50 „

1 590 F. s.

Below 1 700 yds.	Add 25 yds.
From 1 700 to 4 100 yds.	„ 50 „
Above 4 100 yds.	„ 75 „

1 580 F. s.

Below 1 200 yds.	Add 25 yds.
From 1 200 to 2 200 yds.	„ 50 „
„ 2 200 „ 4 100 „	„ 75 „
„ 4 100 „ 8 000 „	„ 100 „

1 570 F. s.

Below 1 500 yds.	Add 50 yds.
From 1 500 to 2 400 yds.	„ 75 „
„ 2 400 „ 4 100 „	„ 100 „
„ 4 100 „ 6 900 „	„ 125 „
Above 6 900 yds.	„ 150 „

1 560 F. s.

Below 1 200 yds.	Add 50 yds.
From 1 200 to 1 800 yds.	„ 75 „
„ 1 800 „ 2 600 „	„ 100 „
„ 2 600 „ 4 100 „	„ 125 „
„ 4 100 „ 6 400 „	„ 150 „
Above 6 400 yds.	„ 175 „

1 550 F. s.

Below 1 000 yds.	Add 50 yds.
From 1 000 to 1 500 yds.	„ 75 „
„ 1 500 „ 2 000 „	„ 100 „
„ 2 000 „ 2 900 „	„ 125 „
„ 2 900 „ 4 100 „	„ 150 „
„ 4 100 „ 6 000 „	„ 175 „
Above 6 000 yds.	„ 200 „

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TABLE 10.—Increase or Decrease of Range.

Apex Angle.	Observed Angle.																Apex Angle.
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	
°	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	°
5	17	29	37	45	50	55	59	62	64	67	70	72	74	75	76	77	78	5
10	9	17	28	29	34	38	42	45	48	51	53	56	58	60	61	63	65	10
15	6	12	17	22	26	29	33	36	38	42	44	46	48	50	51	53	55	15
20	5	9	13	17	21	24	27	30	32	35	37	40	42	44	45	47	49	20
25	4	8	11	14	17	20	23	26	28	31	33	35	37	39	40	42	45	25
30	3	7	10	13	16	18	21	23	25	28	29	31	33	35	36	38	40	30
35	3	6	9	11	14	16	18	21	23	25	27	29	31	33	34	35	37	35
40	3	5	8	10	12	15	16	19	21	23	25	27	28	30	31	33	35	40°
45	3	5	7	9	11	13	15	18	19	21	23	25	27	28	30	31	33	45°
50	2	5	7	9	11	12	14	17	18	20	22	23	25	27	29	30	32	50°
55	2	4	6	8	10	12	14	16	17	19	21	22	24	25	27	29	31	55°
60	2	4	6	8	10	11	13	15	17	18	20	21	23	24	26	28	30	60°
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	

For explanation, see pp. 23, 24.

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TABLE 11.—Deflection Angle.

B.T. / O.T.	Observed Angle. 1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	B.T. / O.T.
1	1° 0′	2° 0′	3° 0′	4° 0′	5° 0′	6° 0′	7° 0′	8° 0′	9° 0′	10° 0′	11° 0′	12° 0′	13° 0′	14° 0′	15° 0′	16° 0′	1
2	30	1 0	1 30	2 0	2 30	3 0	3 30	4 0	4 30	5 0	5 30	6 0	6 30	7 0	7 30	8 0	2
3	20	40	1 0	1 20	1 40	2 0	2 20	2 40	3 0	3 30	3 40	4 0	4 20	4 40	5 0	5 20	3
4	15	30	45	1 0	1 15	1 30	1 45	2 0	2 15	2 30	2 45	3 0	3 15	3 30	3 45	4 0	4
5	10	25	35	50	1 0	1 10	1 25	1 35	1 45	2 0	2 10	2 25	2 35	2 50	3 0	3 10	5
6	10	20	30	40	50	1 0	1 10	1 20	1 30	1 40	1 50	2 0	2 10	2 20	2 30	2 40	6
7	10	15	25	35	40	50	55	1 5	1 15	1 20	1 30	1 35	1 50	1 50	1 55	2 5	7
8	5	15	25	30	40	45	50	1 0	1 10	1 15	1 20	1 30	1 40	1 40	1 50	2 0	8
9	5	15	20	25	35	40	45	55	1 0	1 10	1 10	1 20	1 29	1 30	1 40	1 45	9
10	5	10	15	25	30	35	40	50	55	1 0	1 5	1 10	1 20	1 25	1 30	1 35	10
15	5	10	15	20	20	25	30	40	50	45	50	55	1 0	1 5	1 10	1 10	15
20	3	5	10	15	15	20	20	25	35	30	30	35	40	40	45	50	20
30	0	5	8	10	10	10	15	15	20	20	20	25	25	30	30	35	30
	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	

For explanation, see pp. 23, 24.

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Ranging on Line of Observation.

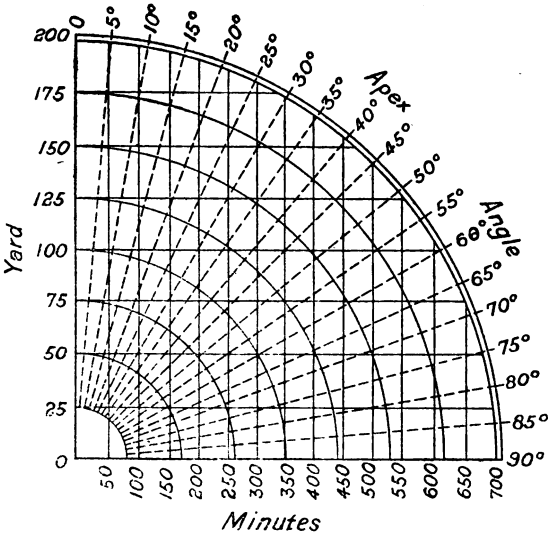

TABLE 12.—Converting Minutes into Degrees.

Min.	1 500	2 000	2 500	3 000	3 500	4 000	4 500	5 000	5 500	6 000
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
100	1 7	0 50	0 40	0 35	0 30	0 25	0 20	0 20	0 20	0 15
150	1 40	1 15	1 0	0 50	0 45	0 40	0 35	0 30	0 30	0 25
200	2 15	1 40	1 20	1 5	1 0	0 50	0 45	0 40	0 35	0 30
250	2 45	2 5	1 40	1 20	1 10	1 0	0 55	0 50	0 45	0 40
300	3 20	2 30	2 0	1 40	1 25	1 15	1 5	1 0	0 55	0 50
350	3 53	2 55	2 20	2 0	1 40	1 30	1 15	1 10	1 5	1 0
400	4 15	3 20	2 40	2 15	1 55	1 40	1 30	1 20	1 15	1 10
450	5 0	3 45	3 0	2 30	2 10	1 50	1 40	1 30	1 20	1 15
500	5 30	4 10	3 20	2 50	2 25	2 5	1 50	1 40	1 30	1 25
550	6 5	4 35	3 40	3 5	2 40	2 15	2 0	1 50	1 40	1 30
600	6 40	5 0	4 0	3 20	2 50	2 30	2 15	2 0	1 50	1 40
650	7 15	5 25	4 20	3 35	3 5	2 40	2 25	2 10	2 0	1 50
700	7 45	5 50	4 40	3 55	3 20	2 55	2 35	2 20	2 5	1 55
Min.	1 500	2 000	2 500	3 000	3 500	4 000	4 500	5 000	5 500	6 000

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Explanation of Tables.

Table No. 10 is used for finding the angle, right or left, required to bring the next shot either on to the target or on to the line O.T. Observe the angle which the burst makes with the target and divide B.T. by O.T., then look along the line from $\frac{\text{B.T.}}{\text{O.T.}}$ to the column of the observed angle of burst and find degrees or minutes required to bring the next burst on to the line O.T. or closer to the target.

Table No. 11 is used for finding the increase or decrease to range to bring the burst on to the target or on the line O.T. As before, observe the angle the burst makes with the target, and from the column of the apex angle follow the line on to the column of the observed angle of burst, multiply the number found by the distance O.T. in hundreds of yards, which will give the increase or decrease to the range according to whether the shots fall short or past the target.

The diagram is used when the burst is on the line O.T.

Estimate as near as possible the distance of the burst from the target along the line O.T., then follow the curved line from that distance to the dotted line passing from the degrees of the apex angle to the left-hand lower corner of the diagram, and read the increase or decrease to range on the right-hand side of the diagram, and find the right or left deflection in minutes at the bottom of the diagram. Table 12 is used for converting minutes into degrees for the battery range.

Example.—Apex angle = 50°; Range = 5 000 yards; O.T. = 1 000 yards; No. 1 burst = 10°. $\frac{\text{B.T.}}{\text{O.T.}} = \frac{5\,000}{1\,000} = 5$. First burst to left of target use Table 1. From $\frac{\text{B.T.}}{\text{O.T.}}$ look along line from 5 to column 10°, find 2°, give 2° more right; No. 2 burst, say, 6° angle from O.P. From Table 2 on along apex angle column follow along line to 6° column, find 12, which, multiplied by 1° (hundreds of yards of O.T.), gives 120. Order 125 yards increase to range. The burst is then nearly on O.T. line. The diagram to

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be used when the burst is on line O.T., say that it is required to increase the range from O. to T. by 200 yards, the apex angle being 50°. From 200 on the top right-hand corner of the diagram follow the circular curve until the line from 50° is reached, then for the increase to the range from B.T.O. follow the line to the right-hand side of the diagram and read 125 yards, which is the increase to the battery range. To find the amount of deflection to be given, follow the line from the intersection of the range curve with the 50° apex angle line straight down to the bottom of the diagram and read about 550′ there; this, divided by 5, for 5 000 yards, gives 110 min. = 1° 50′. This can be found from the table below by following the line from 550 in the first column (minutes) to the 5 000-yards column, where 1° 50′ is found. The order would be 125 yards more range, 1° 50′ more left.

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Sequence of Orders.

1. Line of fire.
2. Deflection for wind.
3. Concentration or distribution.
4. Nature of ammunition, propellant, projectile, charge for howitzer, and fuze.
5. Angle of sight.
6. Method of ranging.
7. Nature of projectile.
8. Corrector (if necessary).
9. First elevation, or elevations.
10. Interval.
11. Order to fire (if under cover).

Change of Position (Capt. goes to B.C.).

Advance.

1. *Prepare to Advance.*—Gun limbers and 1st line wagon sent up. F.B. remains for Capt. to move.
2. *With F.B. Wagons prepare to Advance.*—Send up gun limber and wagon teams.
3. *Prepare to Limber up.*—Guns run back, limbers sent up.[1] Independent limbering up. First line wagons to place of assembly, also guns. F.B. wagons remain on pin.

Retire.

1. *Prepare to Retire.*—Send up gun limbers and wagon teams.
2. *To Retire, prepare to Limber up.*—Few rounds on ground, run back wagons by hand, teams sent up as required, and then driven to place of assembly, then withdrawn likewise.

Battery Staff.

B.C. Asst. H.H. Mtd. Ordy.	=	B.C.'s Party.
R.O. Asst. H.H. . .		R.O.'s ,,
Capt. 2. M.S. H.H. . .		Capt.'s ,,
B.L.		With Battery.
B.S.M.		,, ,,
Three T'phonists, H.H. ("A")		,, ,,
R.T. H.H.		,, ,,
Two Lookout men . .		,, ,,
Two T'phonists, H.H. ("B")		,, ,,
At Reconnaissance . .		B.C. and R.O.

[50 yds.] B.C. Asst., M.O. H.H. [75 yds.] R.O.'s Asst. H.H. [any] Capt. 2 M.S. H.H. [any] B.L., and remainder with Battery.

[1] Independently

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Use of Director.

No. 1 *Director.*—Set up director with 180° towards target, the plate must be approximately levelled to read true horizontal angles and legs sufficiently splayed to give stability. The director must never be turned by taking hold of the ruler itself, but by turning the top plate.

1. Always lay the director on the target or line of fire with the arrow clamped at zero. All angles beteeen A.P.'s or mag. north and the line of fire are then read R. or L. of zero, just as they should be given to the battery.

2. To give an angle to another director or the dial sight of a gun (which will be required to lay on your director), lay fore-sight-backsight on them. If you send this angle just as you read it, they have an angle which will enable them to obtain a line parallel to your director (when on the zero line) by laying with this angle on your director.

3. When you receive an angle from director, clamp your own director at the angle sent to you, and lay on director or point (mag. N.). When the arrow of the plate has been turned to zero, your director will be pointing in the required line.

No. 4 *Director.*—Rules for No. 4 same as above (except for rule 2), lay in normal way, and read angle under dot. If no dot, read under arrow; subtract from 180°, and call right, left, and vice versa.

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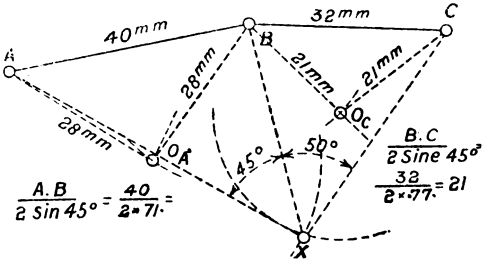
Diagram for Finding Position on Map,

showing method of locating positions on a map by means of angles measured between three known points. Let A, B, C be three points marked on the map, X the unknown position to be located, measure the angles A X B and B X C, scale off the distances between A, B and B, C, divide these distances by twice the sine of their subtended angles, and with these distances mark points O*a* and O*c* from A, B and B, C. From O*a* and O*c* as centres describe two circles, then their point of intersection will be the point X.



Note.—The best results will be obtained if the measured angles exceed 45° each.

TABLE 13.—Natural Sines.

°	Sin.	°	Sin.	°	Sin.	°	Sin.	°	Sin.	°	Sin.	°	Sin.	° Sin.
1	·02	13	·22	25	·42	37	·60	49	·75	61	·87	73	·96	85
2	·03	14	·24	26	·44	38	·62	50	·77	62	·88	74	·96	1·
3	·05	15	·26	27	·45	39	·63	51	·78	63	·89	75	·97	86
4	·07	16	·28	28	·47	40	·64	52	·79	64	·90	76	·97	1·
5	·09	17	·29	29	·48	41	·66	53	·80	65	·91	77	·97	87
6	·10	18	·31	30	·50	42	·67	54	·81	66	·91	78	·98	1·
7	·12	19	·33	31	·52	43	·68	55	·82	67	·92	79	·98	88
8	·14	20	·34	32	·53	44	·69	56	·83	68	·93	80	·98	1:
9	·16	21	·36	33	·54	45	·71	57	·84	69	·93	81	·99	89
10	·17	22	·37	34	·56	46	·72	58	·85	70	·94	82	·99	1·
11	·19	23	·39	35	·57	47	·73	59	·86	71	·95	83	·99	90
12	·21	24	·41	36	·59	48	·74	60	·87	72	·95	84	·99	1·

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Testing Sights. Use Distinct Object 1 000 Yards away. 18 pr. (in the Field).

For Line.—Remove striker and lay bore for line on ob. by firing-hole bush and cross treads. Tele. on ob. and def. scale at zero, the tele. is in adjustment. If not, then adjust bush on pivot of sight-bar until pointer on Ob. Vertical line of dial sight adjusted by micrometers and set to zero, and, if necessary, the pointer on carrier.

For Elevation.—Tele. collimated before doing tests; lay on ob. with tele. If open sights not agreeing, adjust acorn. If dial not agreeing, revolve micro. top of dial, loosen top clamp, and make micro. read zero.

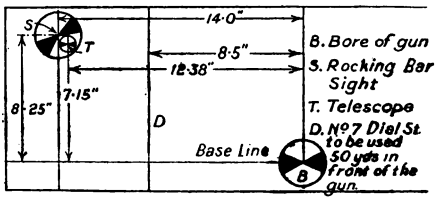
Field Clinometer.—Clean clino. plane; set clino. zero on plane; pivot pin to front and level gun; turn clino. about; if bubble not level = ½ error reading = index error. Set slider to ½ error, level gun, place slider to zero, manipulate capstan head nuts, turning with wire until bubble at zero.

Sight Clinometer.—Fd. clino. at zero on S. clino. bracket; level bubble by hand-wheel; place S. clino. in bracket; if bubble not central adjust micro. heads and pointer and reclamp at zero.

Range Indicator (mark 1 carriage).—Sight clino. at zero. Fd. clino. at zero on guides near muzzle; depress by right-hand wheel till fd. clino. bubble level. If indicator not reading zero, loosen nut and adjust. Droop can now be measured by placing fd. clino. on gun plane and level bubble by slider. Droop should be known to all.

Note.—Mark 1* and 1** carriages. Procedure same, except that fd. clino. is put on guides set at 12′ elevation (arc to rear) instead of zero.

Target for Testing Sighting Gear.



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Testing Sights (in the Field use Object 1 000 Yards off). 4·5 Q.F. How.

Cross Level.—Mark 1 carrier. Fd. clino. on clino. plane, then transversely on top of carrier at zero. If bubbles not agreeing, adjust cross level bubbles. Mark 1* and mark 2 carriers as above, but 4° on fd. clino. arc to the left.

Sight Clinometer.—Level gun, fd. clino longitudinally on carrier at zero and level with range drum hand-wheel, then level sight by mirco. heads and adjust.

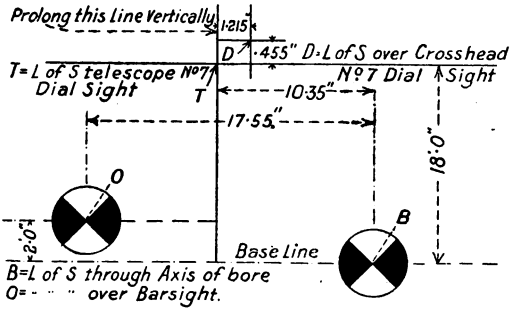
Range Drum.—Gun level; level sight-clino. with range drum hand-wheel. If drum not at zero loosen nut and withdraw drum and hand-wheel downwards; hold drum at zero, and level bubble with hand-wheel, then engage hand-wheel and refit nut. Also adjust at 3 500 yards with shell in bore.

Dial Sight and Carrier for Line.—Dial sight at zero; lay gun through firing-hole bush and cross wires on object; then lay dial sight and adjust micro. heads and pointer.

Dial Sight for Elevation.—As above, lay through hole and cross wires, then through dial sight and adjust cowl to read zero.

Bar Sight.—Lay by cross wires through gun, then over sight set at zero. Adjust for elevation by turning foresight, and for deflection by deflection bar.

Target for Testing Sights. Q.F. 4·5-inch How.



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Apex Angle.

$$\frac{6}{10} \times \frac{\text{True base in yds.}}{\text{Range O.T. in 100 yds.}} = \text{degrees.}$$

Sine and Cosine.

If angle under 80°, add 2 to first fig. = sine.
„ „ over 100, deduct first 2 figs. from 20 = sine.
Sine of angle subtracted from 1·3 = cosine.
Sine 70° = ·9, sine 120° = ·8, sine ·7 cosine = ·6.

Known Base.

$$\frac{30}{\text{Apex angle in degrees}} \text{ for 50 yards sub base} = \left\{\begin{array}{l}\text{100 yards in} \\ \text{known base.}\end{array}\right.$$

$$\frac{15}{\text{Apex angle in degrees}} \text{ for 25 yards sub base} = \left\{\begin{array}{l}\text{100 yards in} \\ \text{known base.}\end{array}\right.$$

True Base.

Multiply known base by sine of exterior angle (ext. angle 80° to 100°, known = true base).

Range. B.T.

Multiply known base by cosine of exterior angle, and if ext. ang. is less than 80°, add result to O.T. = B.T.

If more than 100°, deduct result from O.T. = B.T. Ext. ang. between 80° and 100° B.T. = O.T.

Battery Angle.

1. Extr. ang. — apex ang. = bty. ang.
2. Ill-conditioned triangles—

Forward 00· $\frac{\text{O.T.}}{\text{O.T.} + \text{O.B.}} \times$ extr. ang. = bty. ang.

Rear (180 — bty. ang.) $\frac{\text{O.T.} - \text{O.B.}}{\text{O.T.}} \times$ interior angle.

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Angle of Sight.

1. $\frac{\text{O.T.} \times \text{B.O.} \pm a^2 \times \text{O.T.}}{\text{B.T.}}$

2. $\frac{\text{Difference of contours in inches}}{\text{100 yds. range}}$ = A. of S. in minutes.

3. Apex ang. $^\circ \times a^1$ in $^\circ$ = min $+ a^2$ in min. = A. of S. B.T.

4. Bty. on slope $\frac{\text{A. of S. between flank guns} \times \text{apex angle}^\circ}{\text{No. of gun intervals}}$
= increase or decrease from one flank gun.

Parallelism.

1. $\frac{\text{Smaller ang. between line of guns and A.P.}}{\text{1 000 yds. to A.P.}}$ = min. con. or dis. from gun nearest director.

2. Guns concentrated on a point. Parallelism =

$$\frac{6}{10} \times \frac{\text{Interval from pivot gun in yds.}}{\text{100 yds. range.}} = \text{deg. distribution.}$$

Concentration and Distribution.

To find constant for any interval $= 72 \times \frac{\text{new interval}}{20}$.

1. $\frac{\text{Extent of tgt. in min.}}{\text{No. of guns.}} - \frac{72}{1\,000 \times \text{range}}$ = min. per gun.
(Assume lines parallel. 20 yards interval.)

2. Subtract ($\frac{1}{3}$ of tgt. + ang. subtend by bty.) from width of battery and divide by number of gun intervals (6-gun bty. only).

Sweeping.

Extent of tgt. in degs. $\times 3{\cdot}5$ or 10 for 6-, 4-, or 2-gun bty. = min. sweep. (Bty. can cover three times its width. Sweep $\frac{1}{2}$ dis.)

Flash and Sound.

Time in seconds between flash and sound $\times 370$ = range in yds.

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Formula for Finding Flash Cover.

Explanation.—The A. of S. from muzzle of gun to top crest or obstruction is obtained, also the A. of S. from top of crest to enemy's O.P. or highest point on ground occupied by him. Add these angles in minutes algebraically together,* multiply by distance from gun to crest in hundreds of yards, and divide this by 12, will give the flash cover for gun in feet.

Example 1.—Range from gun to crest 200 yards. A. of S. to crest from gun +3°, A. of S. from crest to enemy O.P. +1°; then $3° - 1° = 2° = 120'$. $\frac{120' \times 2}{12} = 20$ feet flash cover.

Example 2.—Range from gun to crest = 350 yards. A. of S. to crest from gun +0° 30′, A. of S. from crest to enemy O.P. −0° 45′; then 0° 30′+45 = 75 min., and $\frac{75 \times 3{\cdot}5}{12} = 21{\cdot}9$ feet flash cover.

* NOTE.—*See* **Flash Cover** *below.*

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Flash Cover.

$\frac{(Ac \pm As) \times d}{12}$ = Feet cover.

Ac = A. of S. to crest in min.

As = A. of S. to tgt. „ „

d = distance to crest in 100 yards.

$+As$ when A. of S. is minus.

$-As$ „ „ „ plus.

Clear Crest.

18 pr. Q.F. = A. of S. to crest + A. of E. in min. (7′ per 100 yards).

4·5 How. = as above, but elevation due to distance of crest varies with charge, *i.e.* 4th charge = normal distance, 5th = $-\frac{1}{4}$ of dis., 3rd add $\frac{1}{4}$ of dis., 2nd add $\frac{3}{4}$ of dis. If A. of S. to tgt. is plus, then shell can clear crest at corresponding reduction in Q.A. If A. of S. is minus, add to Q.A. to find lowest elevation.

Double Displacement.

If switching towards battery side of line O.T., *measured switch angle at O + old apex angle − new apex angle* = switch angle at battery. If switching towards O.P. flank, *measured switch angle at O − old apex angle + new apex angle* = battery switch.

Ranging Line O.T.

If apex angle under 45°, get on line O.T. by defn.

„ „ „ over „ „ „ „ ranging.

To keep on line O.T. $\frac{\text{Ang. O.T.B. (apex angle) in min.}}{\text{100 yds. range B.T.}}$

Angles from Mag. North.

Battery and M.N. on same side of line O.T., add apex angle; if opposite sides, deduct.

Time of Flight.

1 000 yards range × 3 = seconds.

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Angle of Descent.

= $1\frac{1}{3}$ times angle of elevation.

Moving Targets.

(Open sights.) Crossing front.

20′ def. for walk.
40′ „ „ trot.
1° „ „ gallop.

Height of Trajectory in Feet.

$4 \times T^2$ (T = time of flight).

Sheet Line Error.

Measure dist. of meridian from a grid at top of map, also at bottom; multiply the diff. by 3 438, and divide by range top to bottom of map = mins. error.

50 % Zone.

Under 3 000 yards, add 2 to hundreds; 3 000 to 3 500 yards = hundreds. Over 3 500 yards deduct 2, 3, 5, 7 and 10 for each 500 yards up to 6 000 yards.

Gunner's Rule.

1 inch = 1 min. in 100 yards.

Ricochet.

Delay action fuzes will not ricochet if angle of descent is more than 8 degrees.

$D \times R = H \times 60$ (57·3).
$D \times R = h \times 20$ (19).
$M \times R = H \times 3\,438$.
$M \times R = h \times 1\,146$.

D = degrees.
R = range in yards.
H = height in yards.
h = height in feet.
M = minutes.

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Value of Angular Wind.

Range.—Cosine of angle of wind from L. of F. × by velocity = F.S. head wind.

Deflection.—Sine of ang. × velocity F.S. = F.S. flank wind.

Level of Wheels.

Difference in inches × degrees of range = min. to higher wheel.

Finding Position on Map.

On tracing paper rule a line representing line to object A. Mark P (= point) anywhere on line ; measure angle to second object B, and draw ray from P ; repeat for third object C. Place paper on map, and move until lines A, B, and C pass through objects on map, then P is your position.

Overestimate concentration, or A. of S., +.
Underestimate distribution, or A. of S., —.

To cover Width of Tgt. with Guns at Irregular Intervals.

Reduce width of tgt. to yds., $H = \frac{D \times R.}{60}$.

Divide by number of guns = dis. in yards for each gun from flank. Reduce diff. of interval (from pivot flank) and distance in yards to inches, and divide by 100 yards gun range = min. dis. as worked out for each gun.

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Explanation of Graph.

By means of this graph the range to a target can be found by aeroplane observations.

The vertical lines are the height of aeroplane in thousands of feet, the horizontal lines the range from battery to target, the diagonal lines the angles the aeroplane makes with a horizontal line from the gun.

Example.—The aeroplane will be flying at a prearranged height, say 12 000 ft., when over a target a signal is made from the aeroplane; the angle sight to the aeroplane at that instant is measured by a clinometer from the gun and the angle read; let this angle = 35°, then follow up the vertical line from 12 to the diagonal line marked 35°, and at their intersection read off on the horizontal lines 5 700 yards.

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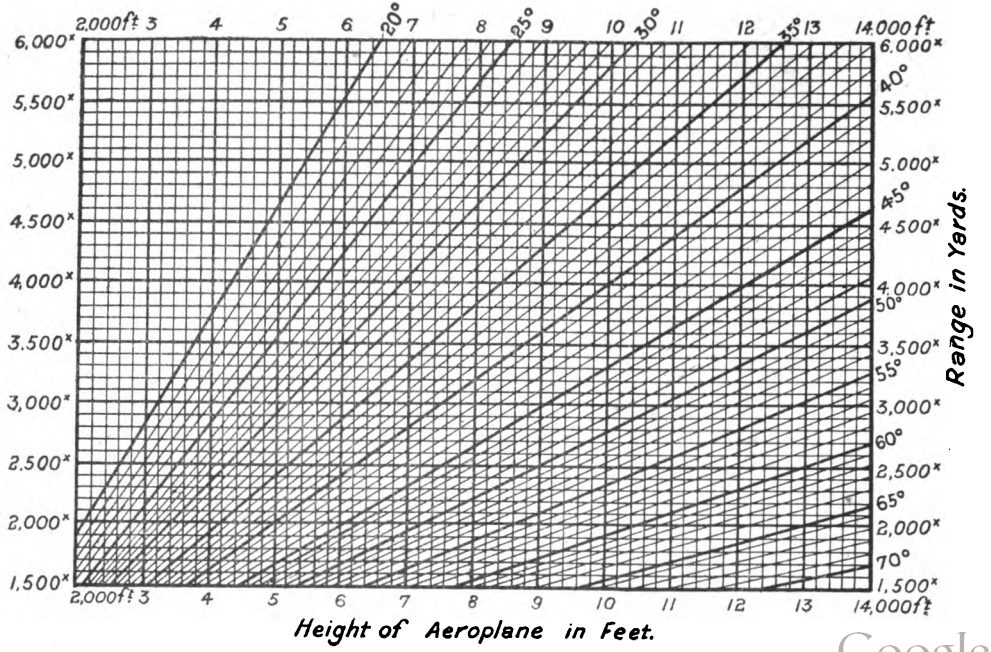

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TABLE 14.—Battery Range and Battery and Apex Angles.

T.O.B. Angle.	O.T./O.B. = 2.			O.T./O.B. = 3.			O.T./O.B. = 4.		
	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier.
°	°	°		°	°		°	°	
30	126½	23½	−·75	137	13	−·77	141	9	−·80
35	119	26	−·70	129½	15½	−·72	135	10	−·70
40	112½	29½	−·60	124	16	−·65	129	11	−·65
45	105½	29½	−·50	118	17	−·57	123	12	−·60
50	99½	30½	−·40	112	18	−·50	117	13	−·50
55	95½	30½	−·35	105½	18½	−·40	111½	13½	−·44
60	89½	30½	−·25	101	19	−·34	106	14	−·37
65	84½	30½	−·20	96	19	−·25	101	14	−·30
70	80	30	−·10	91	19	−·12	95½	14½	−·20
75	75½	29½	−·00	86	19	−·10	90½	14½	−·15
80	71	29	+·10	81	19	Nil.	85½	14½	−·05
85	67	28	+·10	76½	18½	+·06	80½	14½	Nil.
90	63½	26½	+·20	71½	18½	+·14	76	14	+·10
95	59	26	+·30	67	18	+·25	71½	13½	+·20
100	55	25	+·40	62½	17½	+·30	67	13	+·30
105	51½	23½	+·45	58½	16½	+·40	62½	12½	+·35
110	48	22	+·50	54½	15½	+·47	58	12	+·45
115	44½	20½	+·60	50	15	+·55	53½	11½	+·50
120	41	19	+·65	46	14	+·60	49	11	+·60
125	37½	17½	+·70	42	13	+·67	45	10	+·65
130	34	16	+·75	38	12	+·73	40½	9½	+·70
135	30½	14½	+·80	34	11	+·77	36½	8½	+·80
140	27	13	+·83	30½	9½	+·82	32	8	+·80
145	23½	11½	+·87	26½	8½	+·86	28	7	+·90
150	20	10	+·90	22½	7½	+·90	24	6	+·90
155	16½	8½	+·93	19	6	+·93	20	5	+·90
160	13½	6½	+·95	15	5	+·96	16	4	+·95

See worked examples on p. 42.

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TABLE 14.—Battery Range and Battery and Apex Angles.

T.O.B. Angle.	O.T./O.B. = 5.			O.T./O.B. = 6.			O.T./O.B. = 7.		
	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier
30°	143°	7°	—·80	144½°	5½°	—·80	145½°	4½°	—·80
35	137½	7½	—·75	138½	6½	—·75	139½	5½	—·75
40	131½	8½	—·60	133	7	—·70	134	6	—·70
45	126	9	—·50	127½	7½	—·60	128½	6½	—·60
50	120	10	—·50	122	8	—·50	123	7	—·50
55	114½	10½	—·45	116½	8½	—·45	117½	7½	—·45
60	109	11	—·40	111	9	—·40	112½	7½	—·40
65	103½	11½	—·30	105½	9½	—·30	107	8	—·30
70	98½	11½	—·25	100½	9½	—·20	102	8	—·20
75	93½	11½	—·20	95½	9½	—·15	97	8	—·15
80	88½	11½	—·10	90½	9½	—·10	92	8	—·10
85	83½	11½	Nil.	85½	9½	Nil.	87	8	Nil.
90	78½	11½	+·05	80½	9½	+·05	82	8	+·05
95	74	11	+·15	75½	9½	+·15	77	8	+·15
100	69½	10½	+·25	71	9	+·30	72	8	+·30
105	64½	10½	+·35	66	9	+·35	67	8	+·35
110	60	10	+·45	61½	8½	+·45	62½	7½	+·45
115	55½	9½	+·50	57	8	+·50	58	7	+·50
120	51	9	+·60	52½	7½	+·60	53½	6½	+·60
125	46½	8½	+·65	48	7	+·65	49	6	+·65
130	42	8	+·70	43½	6½	+·70	44½	5½	+·70
135	37½	7½	+·80	39	6	+·75	40	5	+·75
140	33½	6½	+·85	34½	5½	+·80	35½	4½	+·80
145	29½	5½	+·90	30½	4½	+·88	31	4	+·85
150	25½	4½	+·90	26½	3½	+·90	27	3	+·90
155	21	4	+·95	21½	3½	+·95	22	3	+·95
160	16½	3½	+OB	17	3	+OB	17½	2½	+OB

See worked examples on p. 42.

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TABLE 14.—Battery Range and Battery and Apex Angles.

T.O.B. Angle.	O.T./O.B. = 8.			O.T./O.B. = 9.			O.T./O.B. = 10.		
	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier.	T.B.O. Angle.	Apex Angle.	Base Multiplier.
30°	146°	4°	−·80	146½°	3½°	−·80	147°	3°	−·80
35	140½	4½	−·75	141	4	−·75	142	3	−·75
40	135	5	−·70	135½	4½	−·70	136½	3½	−·70
45	129½	5½	−·60	130½	4½	−·60	131½	3½	−·60
50	124	6	−·50	125	5	−·55	126	4	−·55
55	118½	6½	−·45	119½	5½	−·50	120½	4½	−·50
60	113½	6½	−·40	114½	5½	−·40	115	5	−·40
65	108	7	−·30	109	6	−·30	110	5	−·30
70	103	7	−·25	104	6	−·25	105	5	−·25
75	98	7	−·20	99	6	−·20	100	5	−·20
80	93	7	−·15	84	6	−·15	95	5	−·15
85	88	7	−·10	89	6	−·10	90	5	−·10
90	83	7	Nil.	84	6	Nil.	85	5	Nil.
95	78	7	+·10	79	6	+·10	80	5	+·10
100	73	7	+·20	74	6	+·20	75	5	+·20
105	68	7	+·30	69	6	+·30	70	5	+·30
110	63½	6½	+·40	64½	5½	+·40	65	5	+·40
115	58½	6½	+·50	59½	5½	+·50	60½	4½	+·50
120	54	6	+·60	55	5	+·60	56	4	+·60
125	49½	5½	+·65	50	5	+·65	51	4	+·65
130	45	5	+·70	45½	4½	+·70	46	4	+·70
135	40½	4½	+·75	41	4	+·75	41½	3½	+·75
140	36	4	+·80	36½	3½	+·80	37	3	+·80
145	31½	3½	+·85	32	3	+·85	32	3	+·85
150	27	3	+·90	27½	2½	+·90	27½	2½	+·90
155	22½	2½	+·95	23	2	+·95	23	2	+·95
160	18	2	+OB	18½	1½	+OB	18½	1½	+OB

See worked examples on p. 42.

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TABLE 14.—Battery Range and Battery and Apex Angles.

T.O.B. Angle.	O.T./O.B. = 15. T.B.O. Angle.	Apex Angle.	Base Multiplier.	O.T./O.B. = 20. T.B.O. Angle.	Apex Angle.	Base Multiplier.
°	°	°		°	°	
30	148	2	—·80	148½	1½	—·80
35	142½	2½	—·75	143½	1½	—·75
40	137	3	—·70	138	2	—·65
45	132	3	—·60	133	2	—·65
50	127	3	—·55	128	2	—·55
55	122	3	—·50	122½	2½	—·50
60	116½	3½	—·40	117½	2½	—·40
65	111½	3½	—·30	112½	2½	—·35
70	106	4	—·25	107½	2½	—·30
75	101	4	—·20	102½	2½	—·20
80	96	4	—·15	97½	2½	—·15
85	91	4	—·10	92½	2½	—·10
90	86	4	Nil.	87½	2½	Nil.
95	81	4	+·10	82½	2½	Nil.
100	76	4	+·20	77½	2½	+·20
105	71	4	+·30	72½	2½	+·30
110	66½	3½	+·40	67½	2½	+·40
115	61½	3½	+·50	62½	2½	+·50
120	56½	3½	+·60	57½	2½	+·55
125	51½	3½	+·65	53	2	+·60
130	47	3	+·70	48½	1½	+·65
135	42	3	+·75	43½	1½	+·70
140	37½	2½	+·80	38½	1½	+·80
145	32½	2½	+·85	34	1	+·85
150	28	2	+·90	29	1	+·90
155	23	2	+·95	24	1	+·95
160	18½	2½	+OB	19	1	+OB

See worked examples on p. 42.

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Table for Finding Battery Range and Battery and Apex Angles.

Explanation of Table.—O.T., O.B., add T.O.B. angle given. Divide O.T. by O.B. and use the column indicated by that figure. Follow the column down to the line for the range from O. to T., the battery and apex angles can be read off at once.

For the battery range correction multiply the figure in the third column by O.B. and add or deduct the correction from O.T. according to the + or − in table.

Example 1.—Let O.T. = 4 000 yards, O.B. = 800 yards, T.O.B. = 50°, then $\frac{\text{O.T.}}{\text{O.B.}} = 5$. Then in column 5, line 50°, read 120° for battery angle; 10° for apex angle; and for corrector to O.T. read −·5, and 800 yards × −·5 = 400 yards. 4 000′ −400 yards = 3 600 = battery range.

Example 2.—Let O.T. = 4 800 yards, O.B. = 600 yards, T.O.B. = 130°, then $\frac{\text{O.T.}}{\text{O.B.}} = 8$. Column 8, line 4, 800 yards, read battery angle, 45°; apex angle, 5°; and corrector = + ·7, and 600+·7 = 420. 4 800+420 = 5 220 = battery range.

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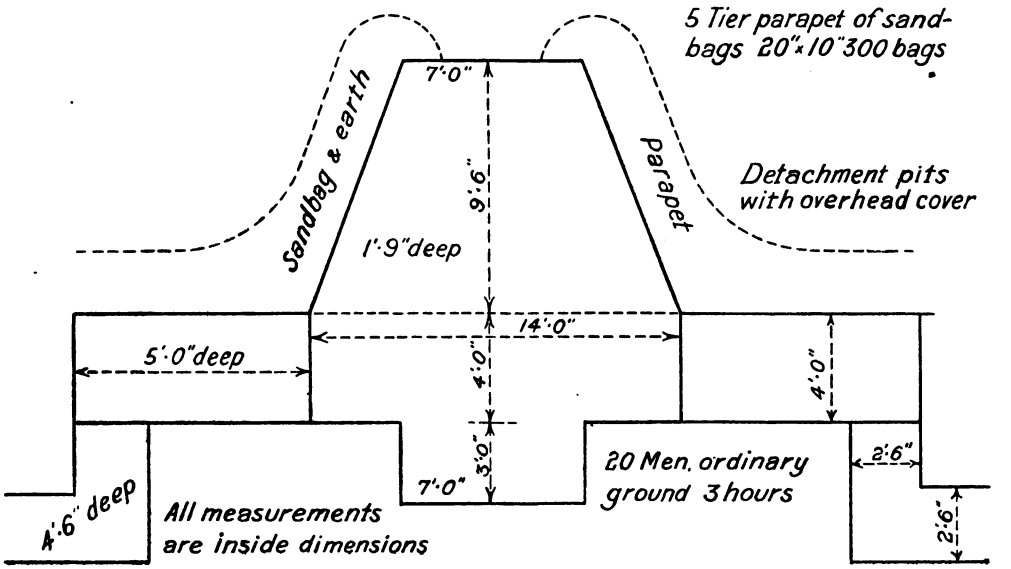

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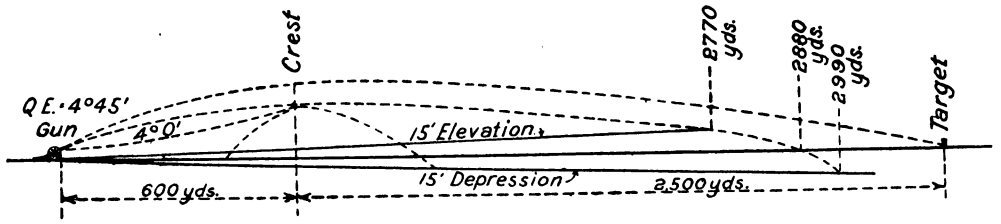
NOTE TO TABLE 5 (Page 15).—Dead Ground and Clear Crest.



Note.—The table is accurate up to 1 000 yards behind crest, beyond that distance additional lines must be added, as follows:—

1 000	yards	to	1 400	yards,	count	one	extra	line
1 400	„	„	1 800	„	„	two	„	lines
1 800	„	„	2 100	„	„	three	„	„
2 300	„	„	2 400	„	„	four	„	„

Example.—Range to crest, 1 300 yards; angle to crest, count 14 lines down from 2°, find Q.E. = 3° 45′, and extreme range 2 425 yards. Dead ground = 2 425—1 300 = 1 125 yards.

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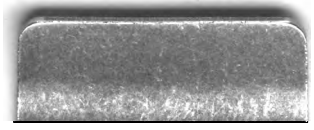

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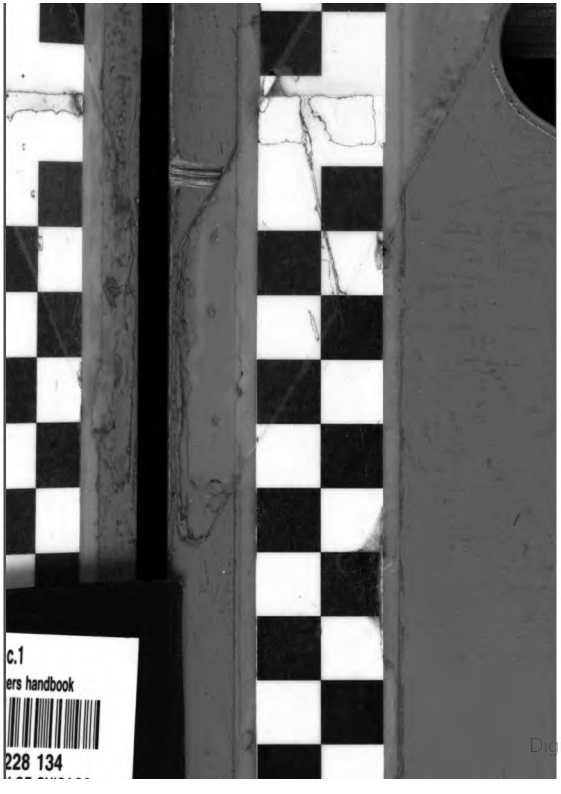

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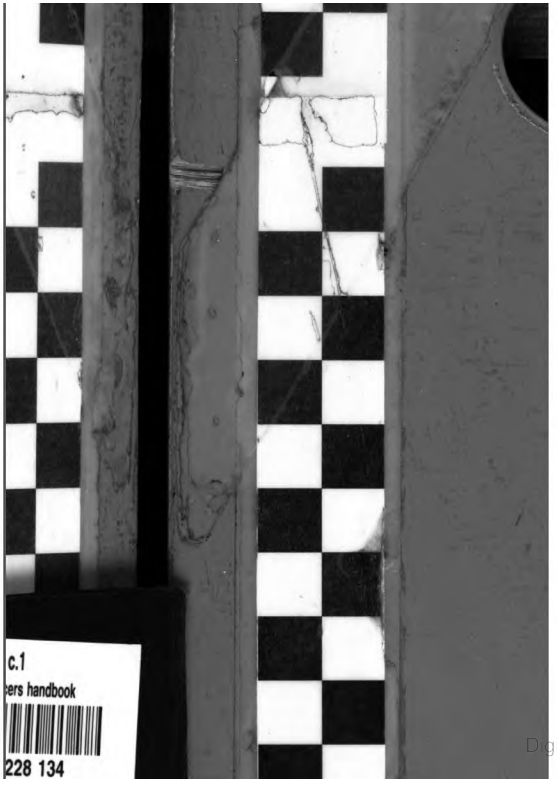

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